

REGOLITH MATERIALS

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Regolith Materials

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2003 National Educators' Workshop

Hampton and Newport News, VA

October 19 - 22, 2003

Goals

- **In-Situ Resource Utilization**
 - using regolith
- **In-Space Manufacturing**
 - fabricating materials
- **Radiation Protection Methods**
 - developing habitat concepts
- **Radiation Physics**
 - measuring radiation transmission

Problem

Martian Environment

- Low-intensity energetic heavy-ion flux of Galactic Cosmic Radiation (GCR)
- Solar Particle Events (SPE)
- Neutron radiation
- Global dust storms (wind speed = 17-30 m/sec)

Mars Exploration Fact

- Earth return possible at specified times (~ every 26 months)

⇒ Need habitat to provide safe haven for human explorers

Martian Regolith (Viking Lander Data)

- Average Density
1.4 g/cm³
- Chemical Composition
58.2% SiO₂
23.7% Fe₂O₃
10.8% MgO
7.3% CaO

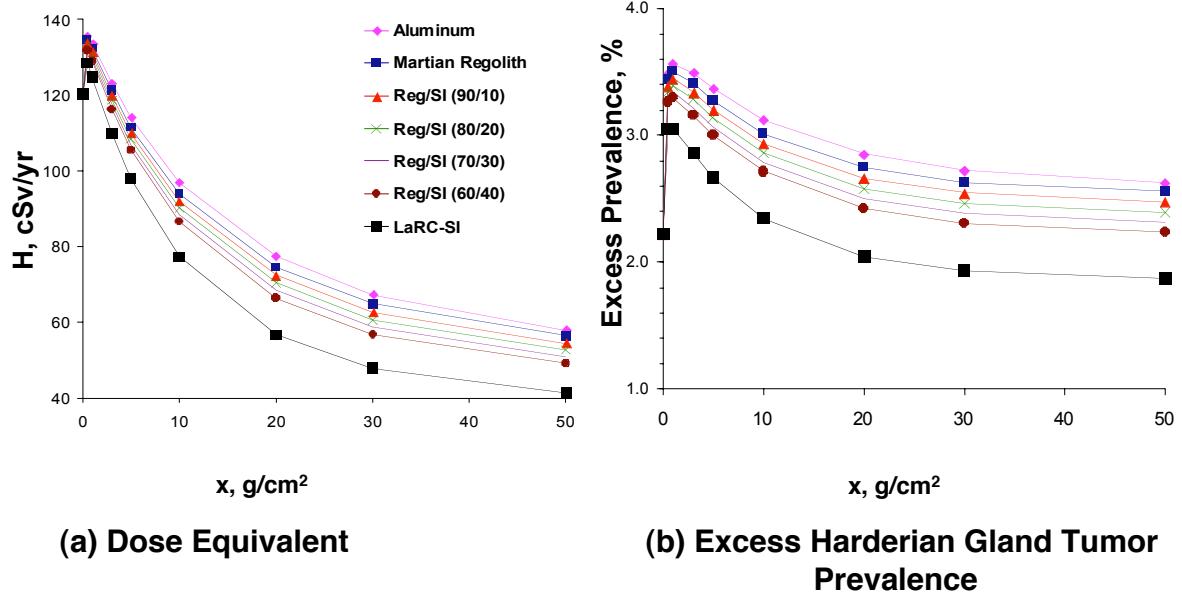
Predicted Annual Dose Equivalent Behind Martian Rocks and Martian Regolith (cSv/yr)

Thickness g/cm ²	Basalt	Lherzolite	Clino- pyroxenite	Ortho- pyroxenite	Dunite	Martian Regolith
1	132.3	132.3	132.4	132.2	132.4	132.3
5	111.5	111.4	111.8	111.1	111.8	111.5
10	94.0	93.8	94.3	93.4	94.3	93.9
30	64.8	64.6	65.2	64.2	65.2	64.8
50	56.5	56.2	56.8	55.9	56.8	56.5

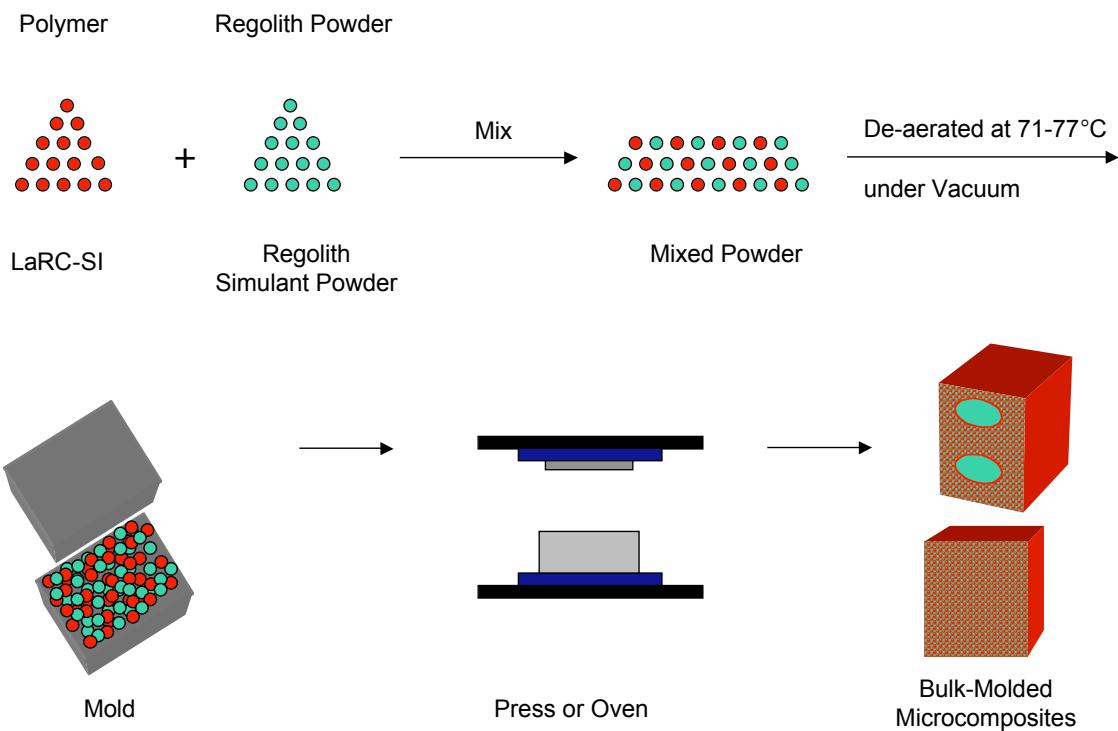
Predicted Biological Responses Behind Martian Regolith and Aluminum After 1-Year GCR Exposure

Thickness g/cm ²	C3H10T1/2 Cell Death Rate, %	C3H10T1/2 Cell Transformation Rate, x 10 ⁻³ %	Excess Harderian Gland Tumor Prevalence, %
Martian regolith			
1	3.92	1.74	3.50
5	3.28	1.65	3.28
10	2.74	1.54	3.02
30	1.89	1.34	2.63
50	1.65	1.29	2.56
Aluminum			
1	3.94	1.76	3.57
5	3.33	1.70	3.37
10	2.80	1.59	3.12
30	1.91	1.39	2.73
50	1.65	1.33	2.63

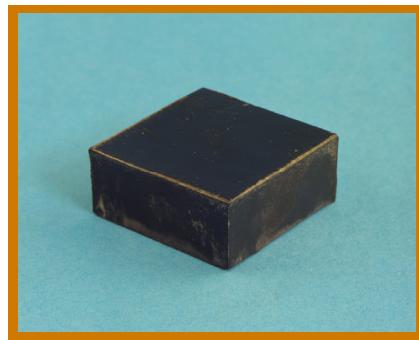
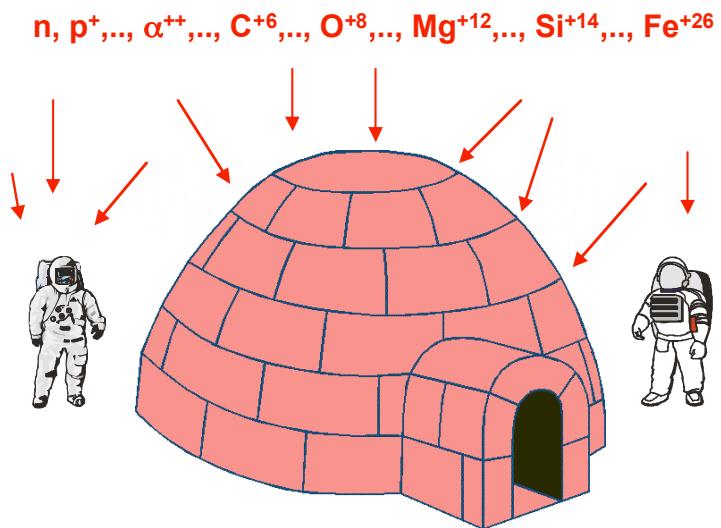
Predicted Biological Responses Behind Various Materials After 1-Year GCR Exposure



Fabrication of Shielding and Habitat Components for Ground Tests



Habitat Construction/Radiation Shielding for Martian Exploration and Development



Regolith/LaRC-SI
(80%/20% by weight)
microcomposite block

Microwave Oven

Manufacturer: Panasonic

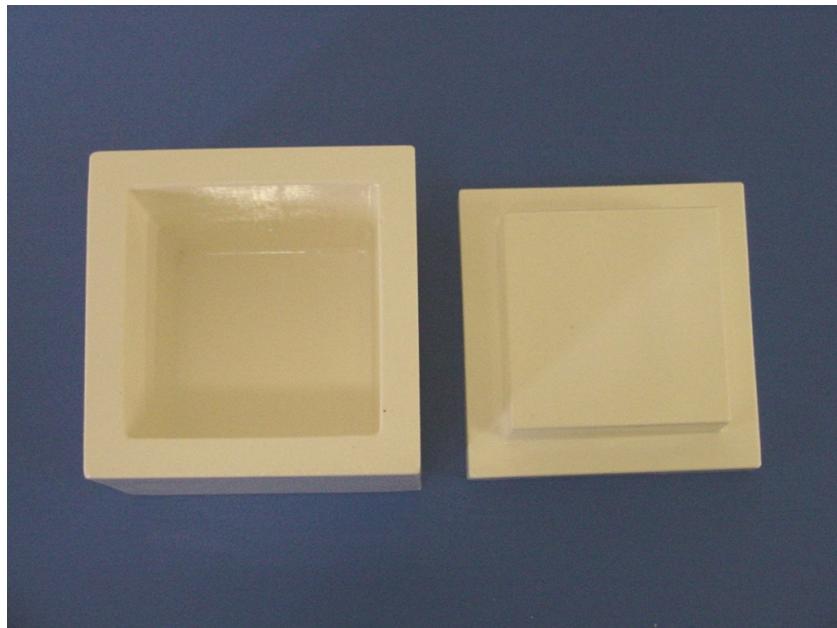
Model #: NN-S950

Oven size: 14" x 23 7/8" x 19 1/2" (h x w x d)

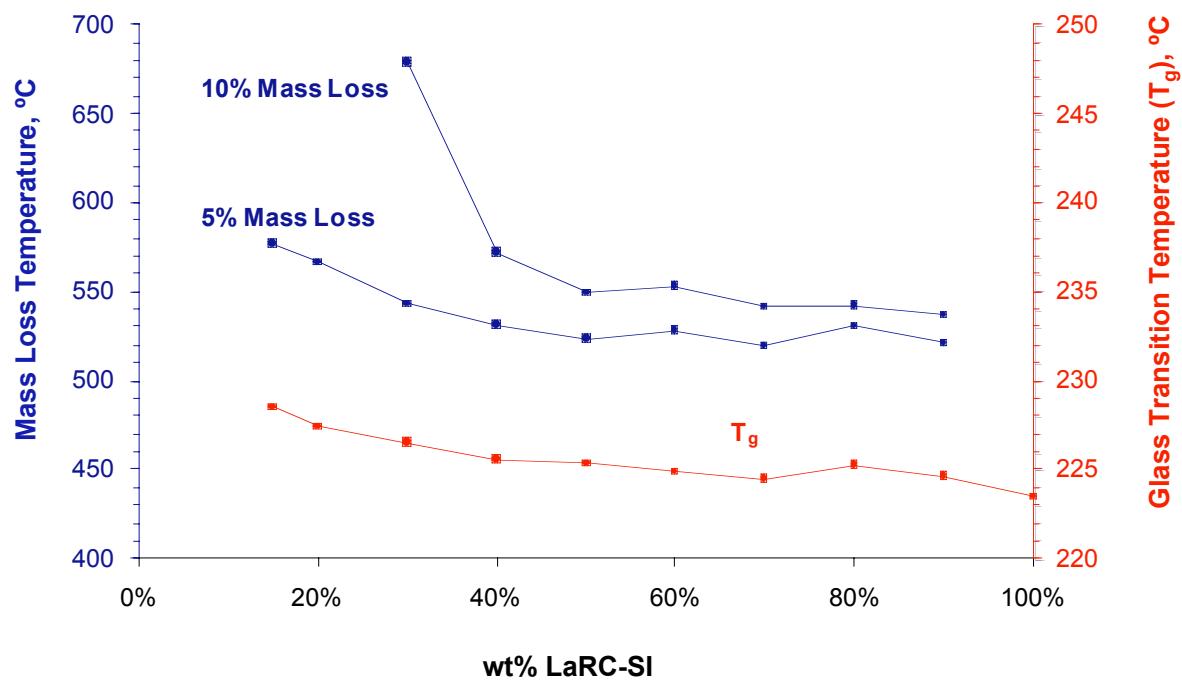
Cavity size: 11" x 18 1/2" x 18 1/2" (h x w x d)

Output: 1300 W at 2.45 GHz

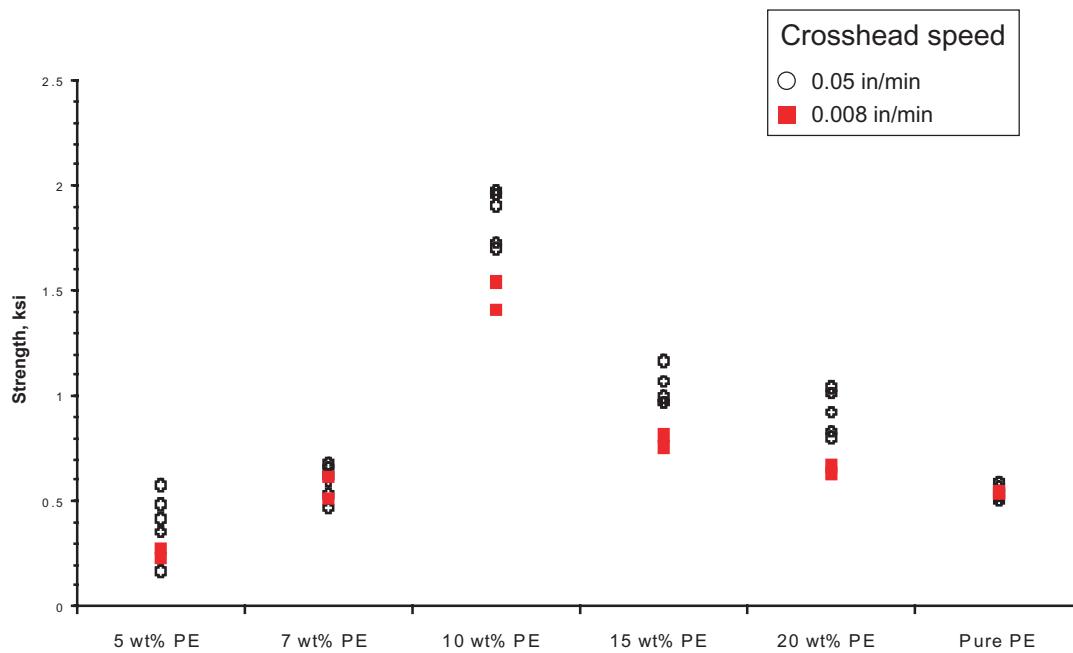
Ceramic Mold for Microwave Processing



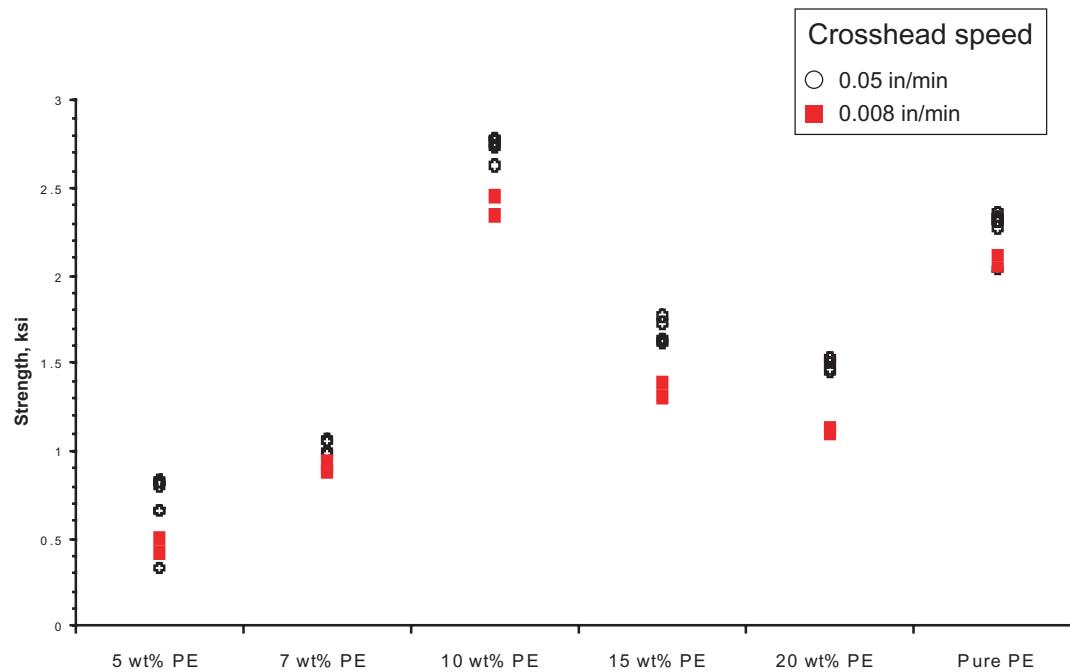
TGA Mass Loss and TMA Glass Transition Temperatures for Regolith/LaRC-SI Microcomposites



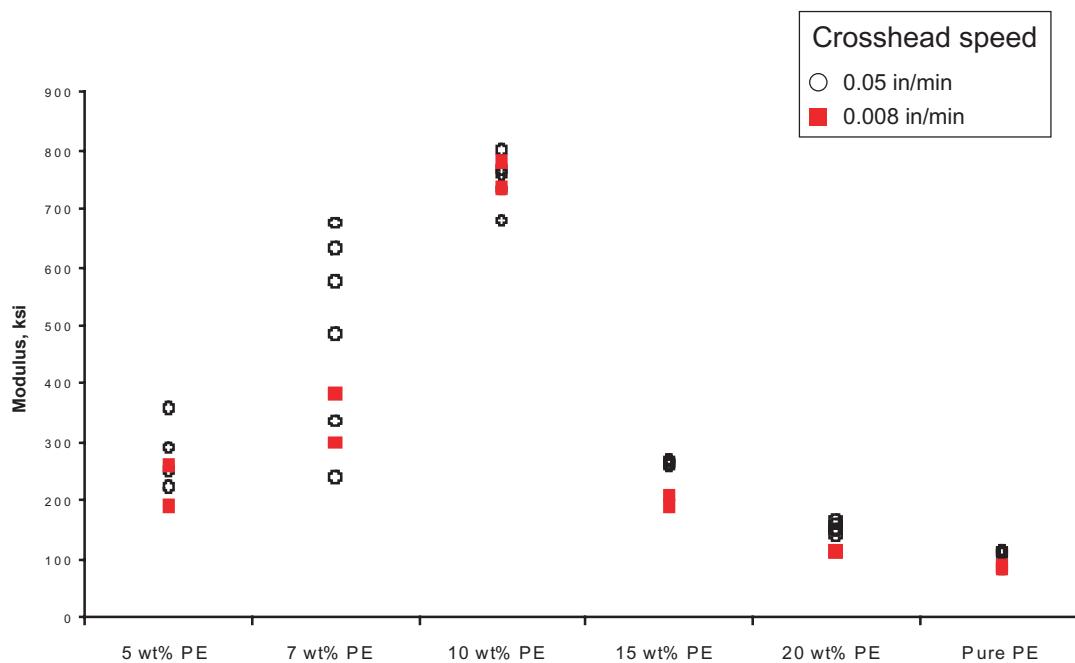
Compressive Yield Strength for Regolith/PE Microcomposites



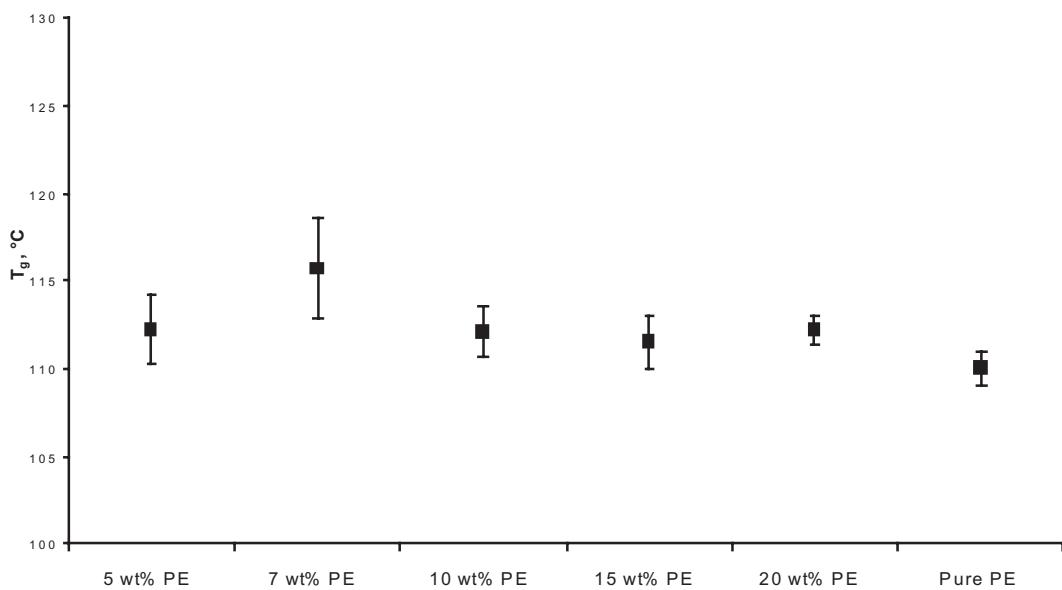
Ultimate Compressive Strength for Regolith/PE Microcomposites



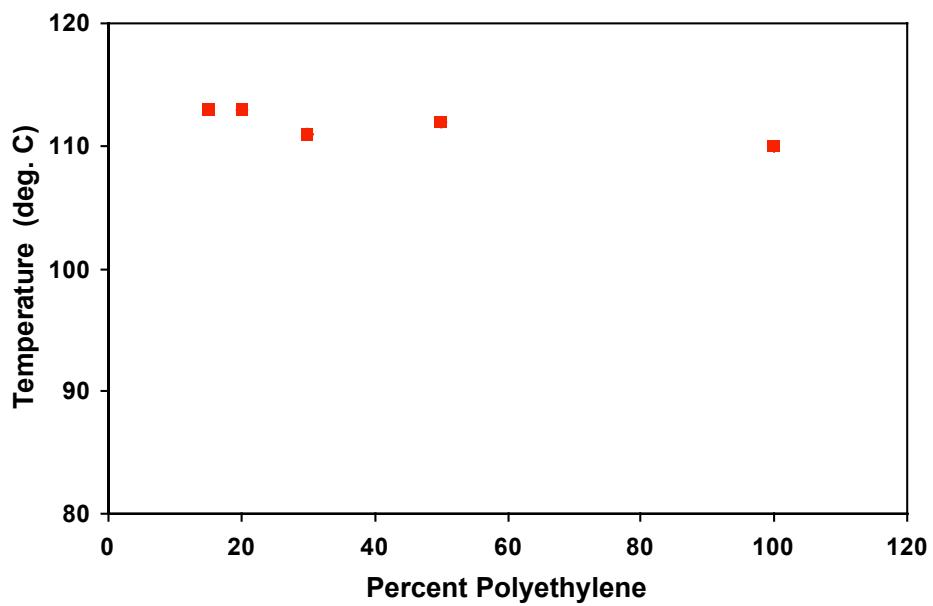
Compressive Modulus for Regolith/PE Microcomposites



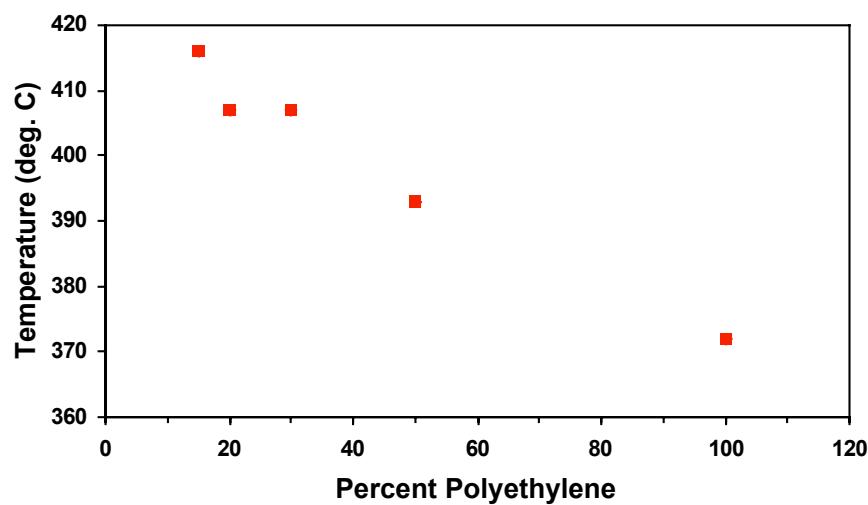
TMA Glass Transition Temperature for Regolith/PE Microcomposites



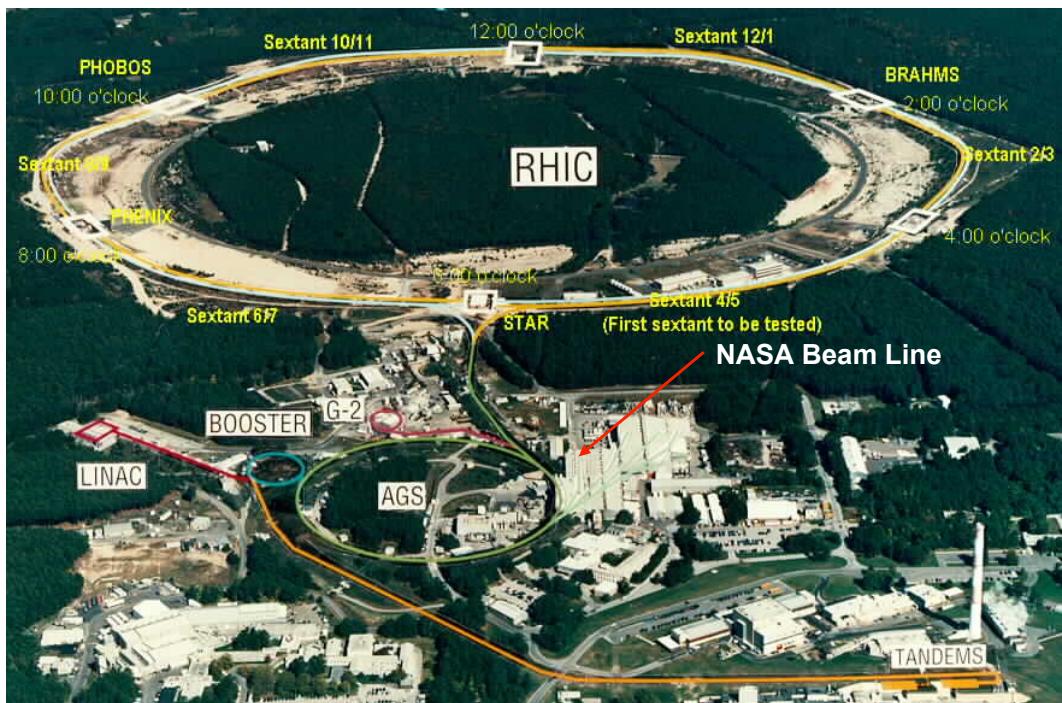
TMA Softening Temperature
for Regolith/PE Microcomposites



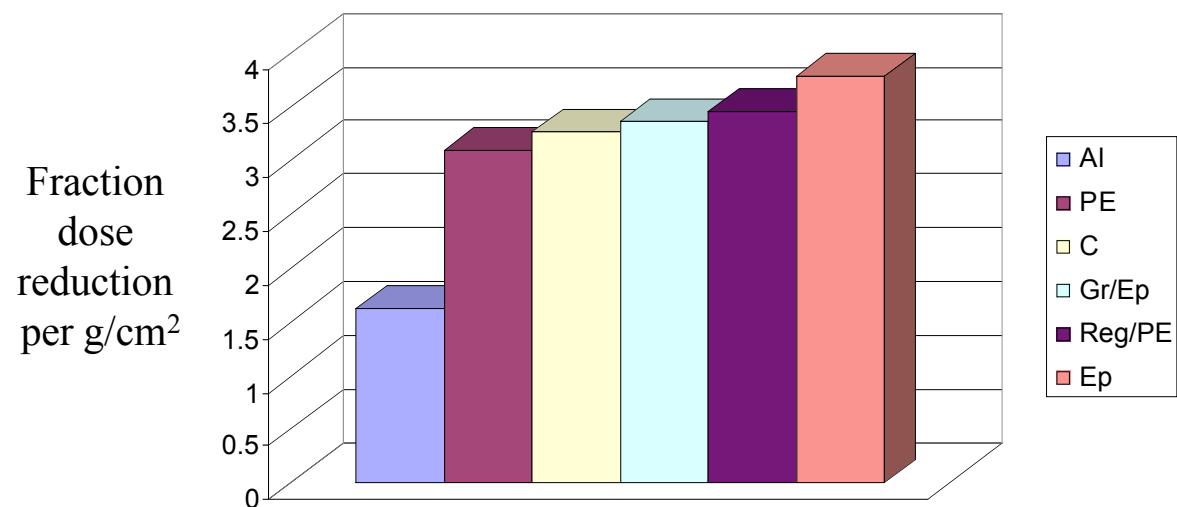
TGA 5% Mass Loss Temperature
for Regolith/PE Microcomposites



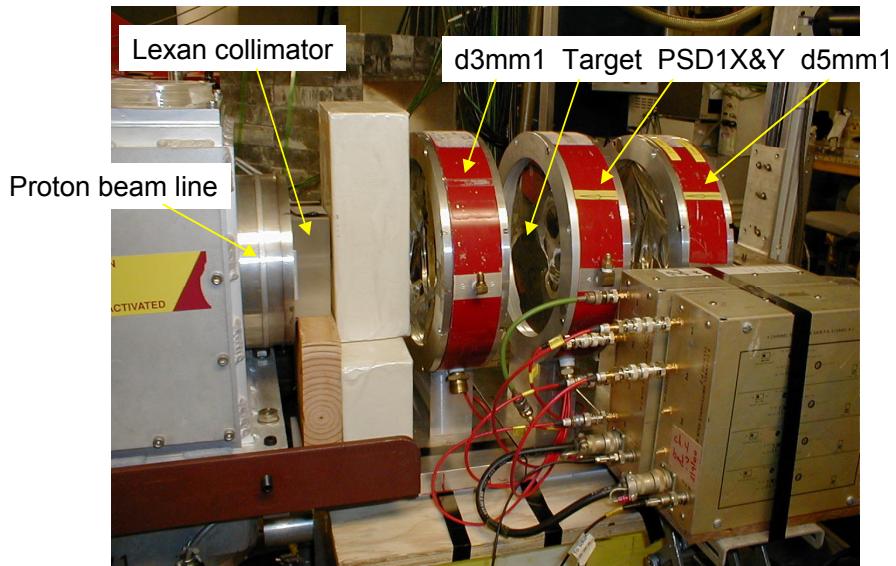
BNL-AGS/NASA Shield Test Facility



Experimental Radiation Shielding Effectiveness of Various Materials for 1.06 GeV Fe Ions

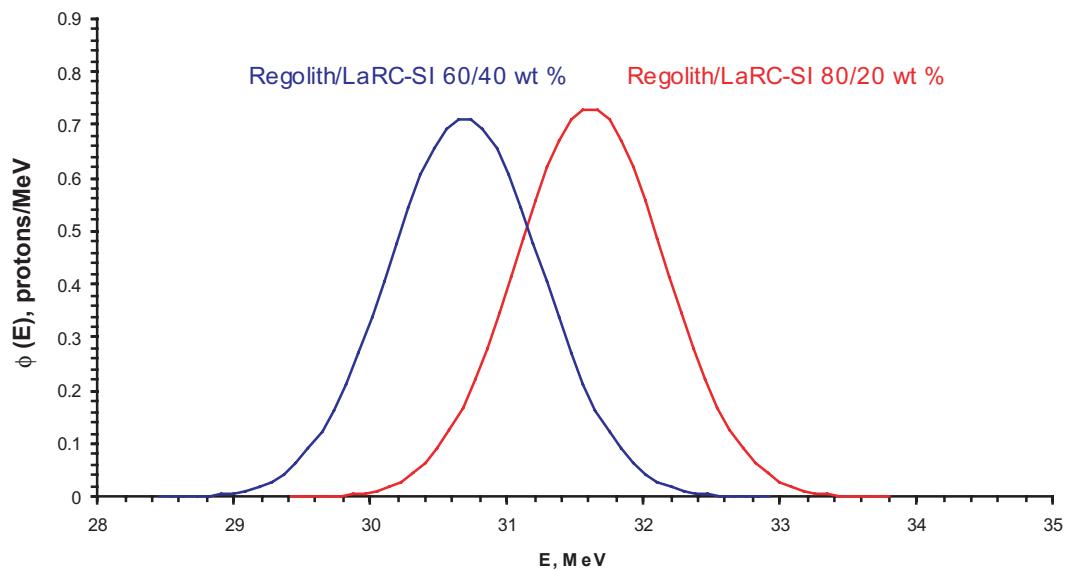


Experimental Setup of 88" Cyclotron at LBNL

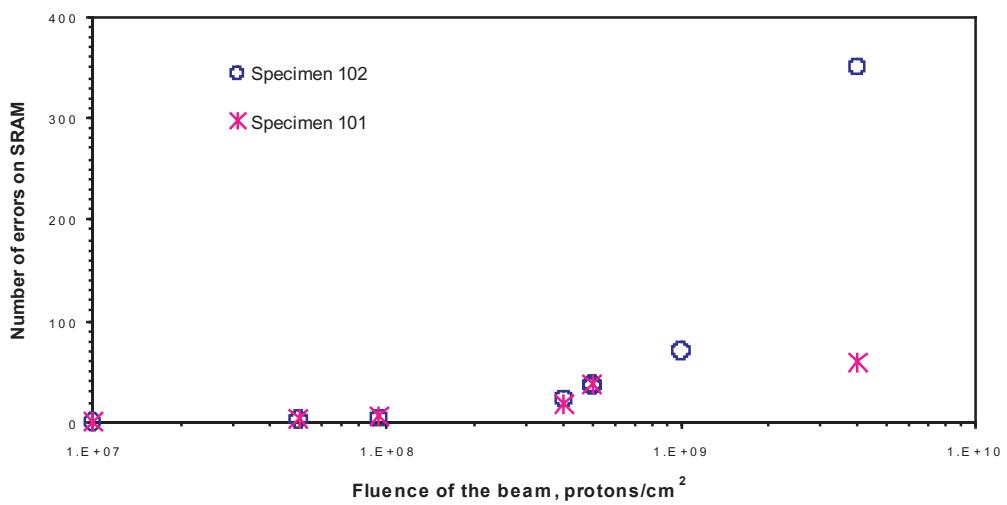


- Nearly Monoenergetic Proton Beam (34.5 ± 0.266 MeV)
- E-Spectrum without Target (23.68 ± 0.46 MeV)
- Statistics (on the order of 1-2 Million Events)

Transmitted Differential Proton Energy Spectrum
for 55-MeV Proton Beam
(2.01 g/cm² thick targets)



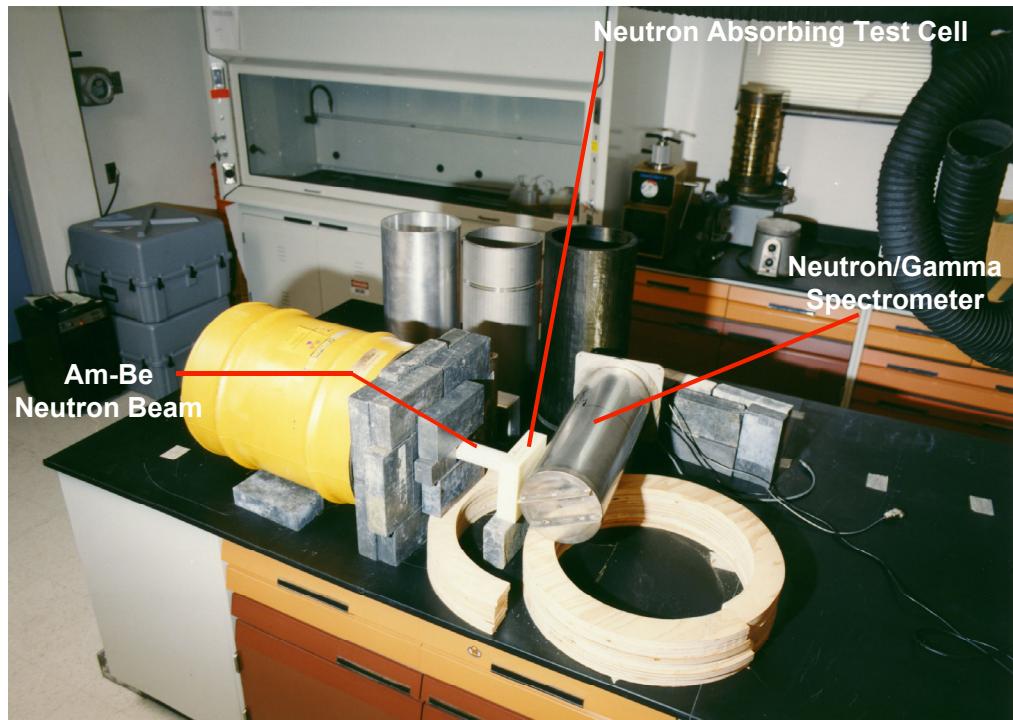
SEU on Motorola MCM6246-5V SRAM from 55-MeV Proton Beam



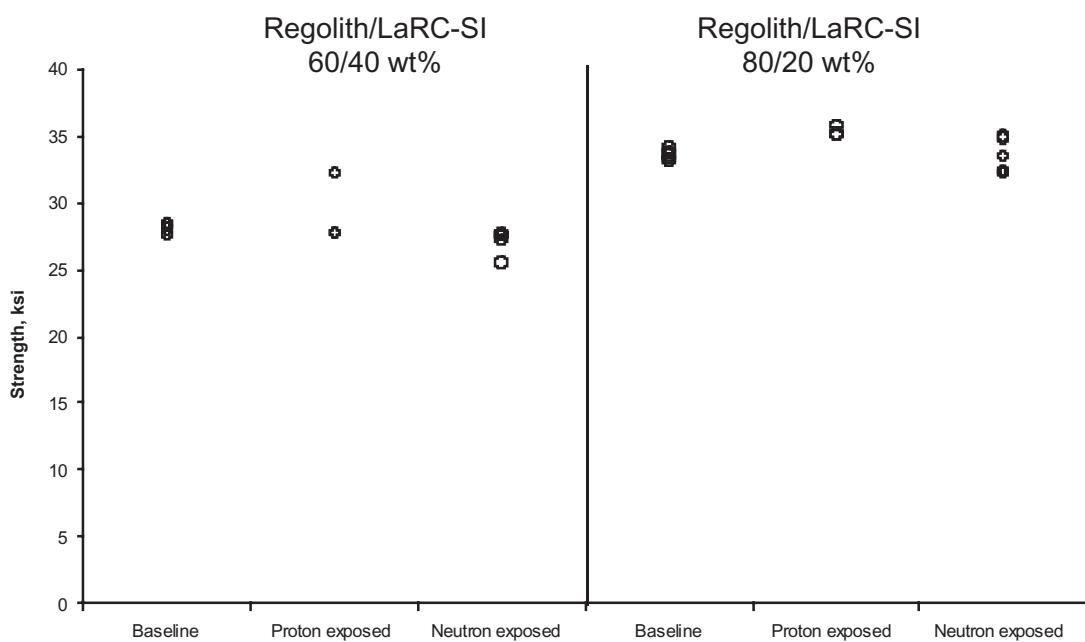
Specimen 102: 80% regolith/20% LaRC-SI

Specimen 101: 60% regolith/40% LaRC-SI

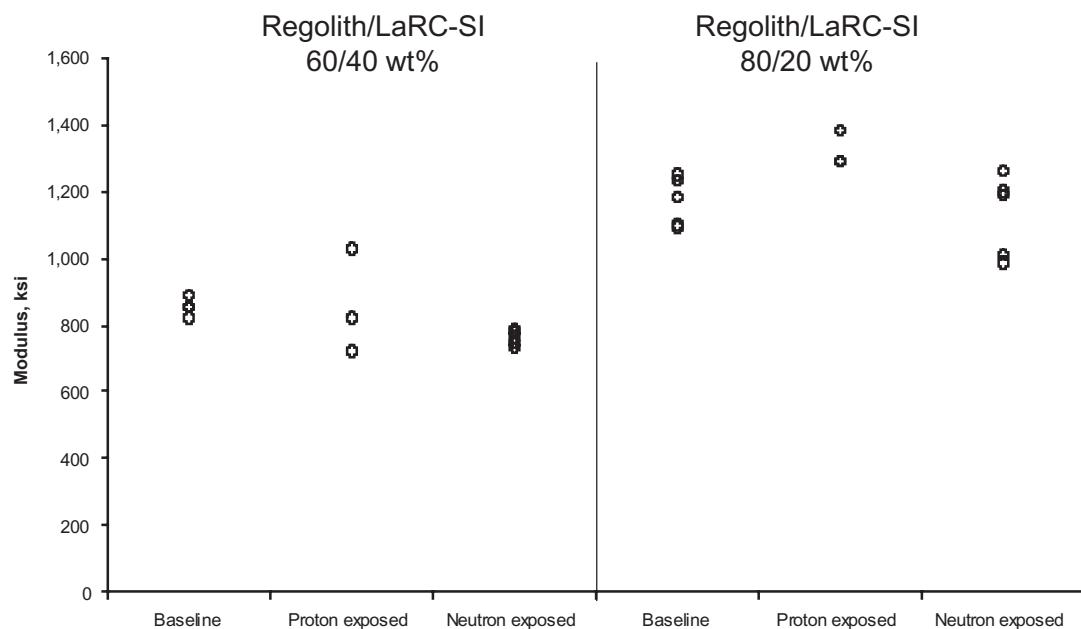
Langley Fast Neutron Shield Test Facility



Ultimate Compressive Strength for Regolith/LaRC-SI Microcomposites



Compressive Modulus for Regolith/LaRC-SI Microcomposites



Multilayered Habitat Concept

